AEOLUS

TO-DAY AND TO-MORROW

For the Contents of this Series see the end of the Book

AEOLUS

OR

THE FUTURE OF THE FLYING MACHINE

BY

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AEOLUS

THE FUTURE OF THE FLYING-MACHINE

INTRODUCTION

The aeroplane is an aerial sailing-ship, its wings are the sails, its source of power the wind. It can claim to be a direct descendant of the family of sailing ships whose father was AEOLUS, god of the winds and the inventor of sails.

Aeroplane, helicopter, ornithopter, rotorplane, and autogiro are sailing-ships because they all derive lift from sails or aerofoils. An aerofoil is a structure so shaped as to obtain a reaction from the wind—a sail is nothing more and nothing less. Whether the wind is natural or is artificially raised by an engine does not affect the function of aerofoil or sail.

The heavier-than-air flying-machine, either engineless glider or power-driven

craft, is the true aerial sailing-ship. The prolate gasbag which is called an airship resembles only one kind of ship, a sinking ship, because it is totally immersed in the fluid which supports it. If a sea parallel to the airship is required, that parallel may justly be said to be the submarine, which is suspended in the water as the airship is suspended in the air.

Before I deal with the future of the aerial sailing-ship I must define three aeronautical terms. No excuse is needed for introducing these apparently elementary definitions since aeronautical terms are almost as well misunderstood by aviators as by laymen. The three terms are :

Wing
Airscrew
Propeller

The definitions I advance are supported by the Royal Aeronautical Society's *Glossary of Aeronautical Terms* and by the British Engineering Standards Association's *Glossary of Aeronautical Terms* although they are often departed

from in official forms and in speech.

Wing. A few days ago I read in a newspaper of a " single-winged airplane ". Accustomed as I am to the aircraft which appear between the drapers' advertisements in the daily newspapers, I was startled at the notion of a " single-winged airplane ". A bird has wings. A single-winged bird would be a queer creature and would be incapable of flying. A " single-winged airplane " would be equally queer and equally earth-bound.

The reporter, in trying to hack out an explanatory synonym for monoplane, docked the aeroplane of one of its wings.

Airscrew and Propeller. An aeroplane can have an airscrew yet no propeller. Most aeroplanes, in fact, are without propellers. In the interests of differentiation it is worth endeavouring to confine the word propeller to the thing that propels or pushes the machine, to use airscrew as a general term, and tractor airscrew when a precise definition is required for the thing that pulls the machine. The colloquialism " prop' " may perhaps be allowed to stand for both tractor airscrew and propeller.

In the following pages I make no attempt to hit upon any sudden invention which may revolutionize flight. I confine myself to developing lines of progress which have already given some proof of practicability. For determining the general trend of progress I rely upon a utilitarian review of the aeronautical situation. I have avoided leaping into the distant future. Readers will be disappointed to learn that things like inter-planetary voyaging are not dealt with in this booklet.

I am aware that scientists have demonstrated that some of the things I do mention are impossible. But scientists have demonstrated that the world is flat, that it is round, and that it is oblong. In the future they will demonstrate that it is rectangular. It was Mr W. N. Sullivan, I think, who said that "To judge from the history of science, the scientific method is excellent as a means of obtaining plausible conclusions which are always wrong, but hardly as a means of reaching the truth." While a few generations can still witness wide variations of opinion among those who know, I incline to the Pyrrhonic doctrine. It is impossible to

know with certainty what is impossible, and in attempting a forecast the best that can be done is to take the trend of contemporary thought and, with that, to build a future upon the principles of the present.

I deal with the future of three kinds of flying-machine, the civil, the service, and the lighter-than-air or airship. The type of machine I say will become popular for short distance air-transport may seem at first to be too unconventional. But I think the whole trend of advanced thought (slotted wings, wingflaps, anti-stall gears and differential ailerons are manifestations of it) is towards the result I suggest.

I

The future of the aerial sailing-ship or heavier-than-air flying-machine will be affected more by the attitude which the world adopts towards it than by technical achievement. In England the national attitude towards machinery is moulded by statesmen and financiers. Under the guise of preserving the liberty of the individual that attitude strangles the life out of the machine; it may be described in the words of the schoolboy who said that *Habeas Corpus* was a phrase used during the great plague of London meaning 'Bring out your dead'.

The statesman has helped to mould the national attitude towards the motor-car through the medium of laws and the manner of their enforcement by his servants the police, and the Courts. The history of the cause and effect of the national

attitude towards the motor-car is being repeated with the flying-machine, and the parallel is close.

Having the safety of the public for its ostensible object, the Motor-Car Act limits the speed of motor-vehicles to twenty miles per hour, proclaims it an offence to drive to the common danger and to be drunk while in charge of a motor-car.

Of the last-mentioned provision I will say nothing beyond mentioning that there are motorists who are incapable of driving safely except when they are drunk. Of the other two, the 20 m.p.h. speed-limit for many years has been generally recognized as having no bearing on safety or danger, whereas for many years motorists have been condemning certain manoeuvres on the road as constituting, legally as well as in truth, driving to the common danger.

The English police, with the connivance of magistrates and Home Secretaries, have concentrated on enforcing the speed-limit and have ignored the dangerous manoeuvres.

This pass has been brought about by

the statesman, who has no direct interest in motor-cars or other new-fangled machines (except when there is a general strike). As a consequence, the car built as a car for speed and control is becoming an object of general dislike. The continued insistance that speed of itself is dangerous and the pompous tyranny of the police (who find motorists tamer and more plastic than thieves) are gradually engendering in the public fear of and dislike for the machine-entity. Instead the wheeled furniture-shop is gaining in popularity. The doctrine of Safety First is threatening initiative and killing the spirit of adventure, while there is ignorance of how to attain safety. Road-racing, the only sure means of increasing car-safety, is prohibited because it is not safe. The result is the dismal, abysmal mess described as the modern British motor-car, which is chiefly remarkable for not containing a single original idea.

Now the result of statesmen moulding a similar attitude towards the flying-machine will be equally dismal. Yet they are already exerting their influence in that direction.

Instead of employing policemen and Courts to harry and hunt the herd of aeronauts, designers, and constructors, however, the statesman employs an army of air-officials. In the world of aeronautics these officials are all-mighty. The private person has no control over them and no reply to them. If he goes to Court against them he will lose. If he appeals against the decision of the Court he will lose again. If he appeals to public opinion he will lose for the third time. The official tells the airman what he may not do, warns the designer of the manner in which he may not design, and informs the constructor how he is forbidden to construct.

The result of this official attitude towards the flying-machine is already faintly visible.

At the time I write Britain holds no world's air-records. For seven years she has made no great flight. She has three or four commercial air-lines against Germany's forty-three. Her fastest aircraft is about 50 m.p.h., slower than the fastest foreign aircraft. Her highest climbing aircraft cannot attain within

thousands of feet of the altitude attained by foreign aircraft. Her longest range aircraft can accomplish little more than half the distance covered by foreign aircraft. Her Air Force can put fewer effective war-machines in the air than any one of three other countries.

One of our pilots has succeeded in proving that, in an English aeroplane, you can go from London to anywhere else more slowly, and in more acute discomfort, than by boat and train.

In one thing only does England excel. She spends more on aviation than any other country in the world.

I am familiar with the excuses for England's aeronautical failings. I know that the House of Commons has been told that there is no object in England attempting to obtain world's air-records. I have heard the claim that the Royal Air Force flies more than any other air force, and I have heard the Air Ministry refuse to supply any figures in support of the claim. I know that the French are said to obtain their high speeds and great distances by cutting down the load factor of their machines. I have been

told about the theory that we *could* gain world's records, run air-lines, win air-races, and have an effective Air Force but that we do not want to do so. I am familiar with these excuses, and, having mentioned some of them, I think I can proceed to indicate a cure for the failings in British aviation. For some cure is the essential preliminary to any future for the flying-machine in England.

The cause of England's aerial impotence is chiefly official interference leading to a wrong national attitude towards the aeroplane.

The cure is to give English aviation the freedom of the air.

If the official is given powers to make vehicular transport safe, he will, as we have seen in the motor-car analogy, infallibly not make vehicular transport safe and he will stop any mechanical development in the vehicle itself. Freedom, then, is the essential condition of aeronautical development.

I said at the beginning of this essay that the financier, as well as the statesman, helped to mould the public's attitude

towards the machine. I speak only of the pure financier or business-man who uses aeroplanes, motor-cars or tin cans with equal indifference as money-making tools; who has no direct interest in any material creation; who repeats that honesty is the best policy and hopes the other man will believe it.

All such business-men in England are humble imitators of American business men. In their advertisements, offices, talk, and indigestion they endeavour as closely as possible to copy the Americans. They therefore believe that, if English people are to produce cars or aeroplanes, they must produce them in the American way—that is cheaply and in mass. Standardization has, in their view, taken the place of craftsmanship and mass-production of hard work.

Already events have shown that the English are incapable of imitating the Americans well. The reason is that the American mechanic regards his work as an unpleasant necessity, to be got through as quickly as possible and to be paid for at as high a rate as possible in order that he may have time and money for the real

purpose of life—doing nothing. The English mechanic, although the statesman is trying to knock such foolishness out of him, still expects to find something satisfying in his work. He still seeks a measure of contentment in the exercise of skill.

Mass-production fits in well with the American workman's ideas: it does not fit in with the English workman's ideas. The English do not and will not produce cheap motor-cars or cheap aeroplanes as quickly and as well as the Americans.

If English flying-machines are to be made capable of competing with American and others, the English, after being freed from official interference, must leave standardization and mass-production to people who are temperamentally suited to them, and instil into these flying-machines some of the idiosyncrasy of their race. Their flying-machines must be creations expressive of the characters of those who design and construct them.

The only English cars having any success in America (and elsewhere) are those few in which perfection of craftsmanship and idealism in design are notable.

They are the kind of cars English designers and mechanics are temperamentally able to produce. The mass-produced cheap English car or flying-machine will remain a feeble imitation of the American. But the idealistic creation, the machine-entity of the English artist-scientist in car or flying-machine has a place to itself in the scheme of things. In its best form it is unique.

The financier's influence in aviation is not yet so noticeable as in motoring, but it is becoming stronger. Should the aeroplane pass entirely into his hands, it will cease to progress as a flying-machine and will start progressing as a bank-note churn. With the future of such an instrument I am unable to deal, since I have no personal experience of either churns or bank-notes.

If it is to make headway as an individual creation the flying-machine must receive the freedom of the air. It must develop its own individuality as a machine-entity. Freedom of the air and the complementary institution of mechanical craftsmanship are the essential conditions for development of the flying-machine. Without

those conditions I have nothing to write of its future. With those conditions the flying-machine presents possibilities of development in high-speed transport that will warrant future generations describing the present age as the static age.

But I must insist that, for the forecast I am now to make, I postulate the gagging and binding or otherwise bottling-up of the statesman and financier.

Only then will this machine-entity, the creation of the artist-scientist, grow. And that the machine-entity, the car or aeroplane as a real and living thing exists will be accepted by all who have spent much time in controlling and looking after high-performance aeroplanes or racing-cars. These machines, built with a single purpose, are sensitive to the treatment they receive as the stone is sensitive to the sculptor's chisel or the violin-strings to the musician's bow.

Turn for one moment from the standard cars, the wheeled furniture-shops " replete with every comfort including cigarette lighter and flower vase " which make hideous our streets to the other extreme

and regard the finely-wrought, aesthetically satisfying racing-car which is to be seen in the American and Continental road-races and occasionally at Brooklands. I do not suggest that racing-cars should be used for transport even in these " most brisk and giddy paced times " ; I merely refer to the racing-car as indicative of a certain attitude towards the machine. The makers of flying-machines should be free, if such is their desire, to aim at the fineness, craftsmanship, and originality in design exemplified in the racing-car.

II

The civil flying-machine, when it is examined in the light of contemporary aeronautical research-work, seems rich in possibilities.

Apart from electrical repulsion, there are five different ways of flying, of which only two are at present in general use, lighter-than-air flight and fixed-wing heavier-than-air flight. I think that a third method is about to be widely adopted, and that this third method will, in time, profoundly influence the whole future of aeronautics.

A comparison between the present system of artificial flight and natural flight will suggest what that third method is.

Let us go to Croydon, the airport of London, and examine a typical three-engined passenger-carrying aeroplane.

The three engines are running, for the machine is about to take off. The coffin-shaped thing whose sides flap in the wind from the airscrews is the fuselage. The machine shows signs of malnutrition, for its bones are prominent in the form of wires and struts. As the engines are run up, the tail shakes and sneezes and coughs until it seems that the fuselage will be ruptured. Now the machine taxis over the aerodrome, its engines open up with a roar, it labours over the ground, and then, looking a little fatigued, it rises into the air.

It passes overhead making a noise like a thunderstorm, shivering and quaking, barging its way along with a clumsy ineffectualness which gives it the appearance of flying through treacle.

When it is out of sight, go to Waterloo Bridge and watch the gulls.

A gull is a hopelessly uncommercial flying machine. It does not pay, it has no ground organization, it is not fitted with wireless, no control-tower informs it when it may land, no books are kept of its mileage or hours flown, no managers, assistant-managers, clerks, secretaries,

typists, accountants, ministers, directors, officials, or meteorologists concern themselves in its safety. No offices, searchlights, flood-lights, neon-lights, leader-cables, or directional wireless stations are set aside for its control and supervision. No treatises are written about its future. A gull is not " a commercial proposition ". It is, however, a good machine for flying.

Neither the superficial nor the fundamental defects of the passenger-carrying aeroplane are present in the gull. The gull is a coherent, unified structure without exposed bracing-wires, struts, or engines. It gets off quickly, flies at a great pace (for its power-loading), is fairly silent and very manoeuvrable, can defeat fog, rain, hail, snow, and gale, and can alight anywhere.

As a flying-machine it owes its basic superiority over the aeroplane to a single, ingenious trick : a trick which looks easy, but which, for many years, the scientist found it impossible to reproduce in practical mechanics.

When flying was first thought about this trick engaged much attention. The mechanical difficulties in reproducing it,

however, refused to be conquered, and about 1680, Borelli, having this trick in mind, wrote: "The Icarian invention is entirely mythical because impossible", a view which, according to Mr J. E. Hodgson's *History of Aeronautics*, was supported by Leibnitz. Afterwards and until just recently the trick has been almost entirely neglected. I think it probable that it will regain its old importance, and that it will become the pivot upon which the whole future of the heavier-than-air land-going flying-machine will turn.

What is this trick which for centuries baffled the mechanician, yet which the gull finds so simple? What is the one fundamental difference between the means employed by the gull for flying and the means employed by the aeroplane?—It is the difference between the fixed wing and the moving wing.

The gull has the trick of being able to move its wings relative to its body. The gull is a moving-wing flying-machine. The conventional aeroplane is a fixed-wing-flying-machine.

Almost every important advantage

which the gull (and any other bird) has over the type of aeroplane which has so far been most popular may be traced to the gull's ability to move its wings. For that reason alone it can get off without a long run, defeat fog and gale, and alight anywhere.

Since the time of the artificial "flying pigeon" of Archytas in the 5th. cent. B.C. the manner of whose flight seems obscure, attempts have been made to build machines which imitate the gull by flapping their wings. Several people, including Bladud, the legendary flying King of Britain, found out in an unpleasant manner that the muscles were not strong enough to actuate man-lifting wings. And in the construction of engine-driven ornithopters the mechanical difficulties invariably proved insuperable. The natural flapping wing has never been exactly imitated by mechanical means in a flying-machine, nor have the leg and foot been exactly imitated by mechanical means in a motor-car.

The motor-mechanician, in using the wheel in place of the leg and foot, imitated the principle employed by nature for land-

locomotion but not the means. Will the aeroplane-mechanician imitate the principle employed by nature for flight but not the means?

The aeroplane-mechanician has already accomplished this feat in a rudimentary form in the Cierva Autogiro, which is commonly (and accurately) called the windmill aircraft.

The helicopter has never achieved much success and, for the present purpose, it may be classed with the ornithopter as obsolete. The autogiro, therefore, is the first practical moving-wing aircraft. It accomplishes that which generation after generation of mechanicians found it impossible to accomplish. It has seized on the bird-principle of flight and translated it into practical mechanics.

III

The existing autogiro, although it may not resemble the more developed types which will eventually appear, is the most successful moving-wing flying-machine yet produced. Señor de la Cierva's work was described by an aeronautical engineer as being of secondary importance only to that of the Wright brothers. That first flush of enthusiasm may be over, but there seems little doubt that future generations will regard Señor de la Cierva as the inventor of moving-wing flight. And I believe that there will be a fierce battle, more prolonged and more vigorous than has ever been fought between two machines, the battle between moving-wing flight and fixed-wing flight. The struggle between reciprocating engine and turbine, broad gauge and narrow gauge, lighter-than-air and heavier-than-air, water-cooling and air-cooling will be as nothing

compared with the imminent struggle between fixed-wing and moving-wing.

The autogiro obtains lift from a *free*, four-bladed windmill. Each blade of the windmill is a wing and is articulated at the root so that its tip can rise and fall. The autogiro is drawn forward by an ordinary aero-engine and airscrew which are entirely separated from the windmill. As the machine is drawn through the air the relative wind, blowing on the blades or wings, rotates the windmill and it lifts the machine. The wings rise and fall, and this beating motion gives the machine a measure of stability.

To exert lift a wing must move through the air.

The moving-wing aircraft derives lift from wings which can move through the air even though the body of the machine be stationary or nearly stationary. In the fixed-wing aeroplane both body and wings must move if the wings are to exert lift.

The difference between moving-wing and fixed-wing aircraft is so important to this discussion that I shall venture to describe it again in different words.

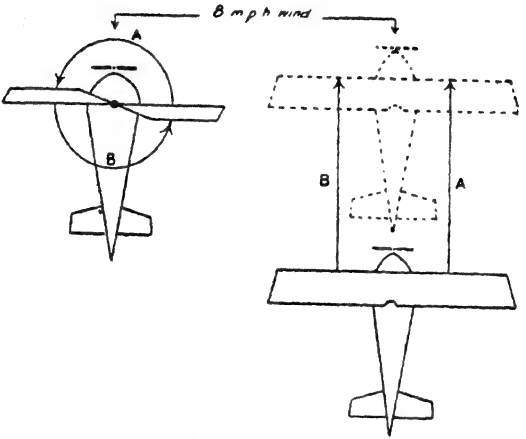

Fig. 1.—Diagrammatic representation of moving-wing and fixed-wing flight. The wings of both machines have travelled equal distances AA and BB but the body of the moving wing machine has remained stationary relative to the ground.

A fixed-wing aircraft is like a bird with its wings paralysed or in splints. A moving-wing aircraft is like a bird having the full use of all its faculties. (Fig. 1).

Perhaps the most important advantage which the moving-wing aircraft has over the fixed-wing aircraft is that it can virtually land on one spot. The conventional aeroplane must move forward in still air if it is to keep up; it must still move forward while landing, and afterwards allow its impetus to be dissipated during a run along the ground.

In addition to this ability to land on a spot, the moving wing aircraft is less likely to become uncontrollable while it is in the air. The fixed-wing aircraft must become uncontrollable in the air if its speed drops below a certain point. This point was called by airmen "the stalling speed". It has needed the mathematician to produce the phrase: "control of stalled aeroplanes". In current English a stalled aeroplane is an aeroplane which is uncontrollable, even if the speed must drop to zero before this condition arises. If any fixed stalling-*angle* can be said to exist outside technical

reports, it is the angle at which the lift of the wings is so reduced that the machine must fall to a nearly vertical position before recovering.

The moving-wing aircraft in the rudimentary form we know it to-day could stall, but it would need a major structural failure or violent and prolonged misuse of the controls to make it do so.

And now one of the weapons which will be used in the battle which I predict between the two main types of heavier-than-air flying machines will be recognized. The weapon of the spot-landing.

Taking advantage of its special characteristics, the moving-wing flying-machine within fifteen years will open hostilities by carrying passengers into and from the hearts of cities and by running safely through fog thick enough to stop other transport services. Up till then the fixed-wing machine with its aerodromes on the outskirts of cities will have held the field almost unchallenged. But whereas the fixed-wing aircraft has now had twenty-two years development, the moving-wing aircraft has had only about three years.

At first, even when it has matured,

people will be shy of the moving-wing machine, and only gradually will it begin to attract passengers used to the other type.

Travellers will begin to realize that, when they go by fixed-wing machines, they waste so much time and suffer so much discomfort in the terminal communications that the advantages of the air-passage are largely neutralized.

At present the air-traveller going from Paris to London spends one and a half hours covering the few miles to and from the aerodromes to the centres of the two cities and only two to two and a half hours covering the 225 miles of the air-journey. Moreover, he changes vehicles twice, at Croydon and at Le Bourget, as he does by boat and train at Dover and at Calais. The aircraft's ability to fly over land and sea alike, therefore, has not given the traveller the advantage of a through-journey. He must taxi from his hôtel in Paris to the place where the air-company's car starts, change from car to aeroplane at Le Bourget, change from aeroplane to car at Croydon, and taxi from the car's stopping place to his home. (Fig. 2).

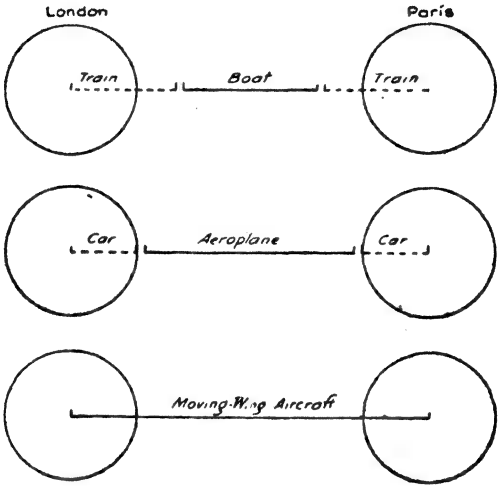

Fig. 2.—Diagrammatic representation of the advantage in flexibility of an aircraft capable of making spot landings and so of using small aerodromes. Alone among vehicles it could provide a through journey to the centres of cities.

The aeroplane dare not risk attempting the journey in thick fog or heavy snow or hail because, in order to support itself, it must move forward through the air at a minimum of say 60 miles per hour. At this speed the pilot, even if aided by a leader-cable, has difficulty in finding the aerodrome in thick weather ; as much difficulty as a motor-car-driver unable to go slower than 20 miles per hour would have in crossing London in a dense fog.

If he thinks he catches a glimpse of a landmark, the pilot cannot stop or slow down and look again to confirm his impression ; he must continue to travel at 60 m.p.h. And if he fail to find the aerodrome he must endeavour to put down his machine—still travelling at 60 m.p.h. —on an area of ground which he cannot see clearly and which he does not know. If a house, ditch, hedge, tree, chimney, shed, road, telegraph wire, pole, or other obstruction is in the way the result is a serious accident.

The disadvantages under which the fixed-wing aircraft suffers when landing and when flying during bad visibility are inherent in the principle of flight it

employs. The moving-wing machine will therefore concentrate its attack at these very points. Since it is able to fly slowly, and virtually to hover, it can feel its way through fairly thick fog. Even if the pilot cannot find the aerodrome, comparatively little danger attaches to a forced landing on unknown ground, because the descent can be made vertically or almost vertically and there is almost no run after touching the ground.

Aerodromes on the roofs of buildings have been foretold with tiresome persistance. A Frenchman succeeded in landing a fixed-wing aeroplane on a roof in Paris. Even so I cannot foresee roof-aerodromes for fixed-wing aircraft, which is the purpose for which former prophets have foreseen them; but I emphatically can foresee roof-aerodromes for slow-landing, moving-wing aircraft.

Travellers going by future air-lines will take a taxi from their homes to Charing Cross, step into a moving-wing machine on a roof aerodrome, fly to Paris, land on another roof-aerodrome near the Place de l'Opéra, and take a taxi to their hotel.

I think it likely that, by the time it reaches maturity, the full speed of the moving-wing aircraft will be below that of the fixed-wing aircraft. But it will make up for this disadvantage by offering travellers the advantages of eliminating terminal communications and changes of vehicle. Part of the time it loses between Croydon and Le Bourget it will regain between Croydon and Charing Cross and between Le Bourget and the Place de l'Opéra. Moreover, on days when, through fog, the fixed-wing aircraft-service is suspended, the moving-wing aircraft will still operate.

By these means the moving-wing aircraft will become a formidable competitor of the fixed-wing aircraft. How will the fixed-wing aircraft reply to the attack?

It will make a supreme effort to increase its speed to such an extent that it will offer to travellers a journey taking from door to door only about two-thirds of the time occupied by the other type. To do this the time lost in terminal communications by motor-car will, at first, be partly recovered by extremely high flying speeds. The 250 miles per hour

air-express will make its appearance. The wing-loading of these machines will be high. Dr Rohrbach the German designer, believes that great advantages accrue through high wing-loadings, and in lectures and papers he has described at length the reasons for his belief. In order to get these highly loaded machines off quickly and to land them within an aerodrome of reasonable size, a form of catapult launching apparatus and an arrester will be employed.

Catapult-launching has been proved, in England, America, Italy, and France, to be practicable with fairly large aircraft. There is no reason to suppose that its development will not continue.

An aircraft-arrester was described by Mr G. H. Dowty in a paper read before the Institution of Aeronautical Engineers in October 1926. It consisted in a drum having wound round it a length of cable. The aeroplane, by some hook and line device similar to that used by Army co-operation machines in picking up messages, will connect itself to the end of the cable. The cable will rotate the drum

against a brake, and the aeroplane will be arrested. Mr Dowty calculates that a machine travelling at 90 m.p.h. could by this means, be brought to a standstill in 100 yards without an excessive strain being put on the machine's structure.

The chances of forced landings in these highly loaded fixed-wing machines will be reduced to a negligible quantity by big reserves of power and by providing that power through many engines.

In spite of the acceleration of the fixed-wing services made possible by the use of these express-aeroplanes, the popularity of the moving-wing services will continue to grow. The public will count time well lost against the discomfort of changing twice and motoring long distances through roads as inadequate for the traffic of that day as the existing ones are for the traffic of this. They will continue to take taxis to the Charing Cross roof-aerodrome when they want to travel by air to Paris, York, Manchester, Glasgow, or Dublin.

The drifting of passengers to the moving-wing services will spur the supporters of the fixed-wing services to

devise another reply. They will build motor speedways from Croydon reaching into the heart of London and from all the other big aerodromes into the hearts of the cities they serve. These speedways will have no side-turnings or cross-roads. They will be forbidden to pedestrians, bicyclists, lorries, 'buses, and similar vehicles. They will be hedged in on either side like railway lines. The flat-footed influence of policeman and politician will be excluded and along these tracks cars will carry passengers to and from the aerodromes at 100 miles per hour. Assisted by these tracks, the great speed of the fixed-wing services will temporarily prevail, and a fair supply of passengers will be assured although the moving-wing services will still flourish.

The position at this stage of the battle might be described as a deadlock. The next stage will perhaps be the most remarkable of all.

It may have been noticed that, unlike most prophets, I have been exceedingly modest in naming the distances over which these future services will operate. While discussing the battle between fixed-

wing and moving-wing, instead of speaking of Empire services, Globe-circling air-lines, or non-stop hemispherical flying expresses, I have spoken of trivial routes like London-Paris and London-Glasgow. I have not even mentioned London-Karachi, London-Melbourne, or London-Montreal.

My modesty was only temporarily assumed. I am now about to throw it off in order to describe what I believe will be the most important development of the flying machine. This development will begin during the latter part of the fixed-wing, *v.* moving-wing battle.

IV

I have spoken, in describing the fixed-wing versus moving-wing battle, only of short air-lines, because I think the establishment of the successful short line will precede the establishment of the long.

It is argued that the saving in time effected by the flying-machine becomes valuable only in long journeys, so that no one would bother to go to an aerodrome and take an aeroplane in order to save half an hour or so, and that the train-service in England is so good that the aeroplane-service would be incapable of competing with it successfully. And, while the disadvantages of short air-services are magnified, the disadvantages of long air-services are forgotten or not appreciated.

At present a short journey of three or four hours by aeroplane is all that the

average passenger can stand in comfort. There is no room for him to move about much in the present cabins, and the noise of the engines, wires, and airscrews is fatiguing to anyone not used to it. Moreover, the time-basis is not the only basis on which the traveller compares the merits of the means of travel at his disposal. The ship provides its passengers with social intercourse and a high degree of comfort. A long journey by sea is usually a pleasant, invigorating experience. On a journey by air, on the other hand, the passengers get no fresh air, they have no opportunity for making friends, for conversation, dancing, games, or any other of the fascinating trivialities which flavour life on board a passenger-steamer. The traveller offered the use of a long distance air-line, therefore, is invited to choose between, perhaps, three days discomfort and isolation in the cramped cabin of an aeroplane and three weeks social pleasure and invigorating laziness on board ship.

Now the disadvantages which attend long-distance air-travel in modern type machines are due almost entirely to the

small size of passenger aircraft when compared with ships. The aeroplane will not be successful as a long-distance vehicle until it can give its passengers most of the pleasures they would get on board ship. It will not be able to give its passengers even a small fraction of those pleasures until it is as large as or nearly as large as the ship.

The pleasures of long-distance travel vary almost directly as the size of the vehicle. Can the aeroplane ever be made so large that it can offer its passengers the space and freedom of even a small-sized passenger-boat?

I do not think the aeroplane can ever become sufficiently big, but I do think the seaplane or the flying-boat can and will become sufficiently big to offer that degree of space and freedom.

I believe that aircraft will begin to compete successfully with boat and train in carrying the merchandize and passengers of the world only after the coming of the era of the hydro-aeroplane (I use this word to include both seaplane and flying-boat).

The longest flight ever made in one

machine was made in a hydro-aeroplane. The largest machines ever built are hydro-aeroplanes. The heavier-than-air machines carrying the greatest weight are hydro-aeroplanes. I am confident that the era of the hydro-aeroplane will come, and that, until it comes, aircraft will not compete successfully with boat and train.

I have based my first conclusion, that the moving-wing aeroplane will become a powerful competitor of the fixed-wing aeroplane for short-distance air-transport, on flexibility. The moving-wing machine can go from door to door, no matter if the journey is partly over the sea and partly over the land. I base my second conclusion, that the hydro-aeroplane will become the pre-eminent vehicle for long-distance air-transport, on size. The hydro-aeroplane can be built as large as may be required.

If people are to journey even for one day in the same vehicle, they need space and freedom of movement. They need wide promenade decks, lounges, restaurants, cabins, smoking-rooms. They cannot be confined to a single basket chair.

For long-distance air-transport the sardine-theory so popular with our London transport controllers must be abandoned. The sardine-theory must be recognized for what it is, a system of getting more money out of the passenger by increasing his discomfort. The more you squeeze the passenger, the more the money oozes out of him.

The aeroplane cannot, I think, become very much larger than the largest machines of to-day because the support of much greater weights on the landing-wheels becomes difficult. At present there are machines in which each landing-wheel must carry 6 tons. If the weight were much increased, the three-point suspension on wheels and tail-skid would become impracticable. The provision of a caterpillar landing-gear and of aerodromes with prepared surfaces might be possible and might assist matters if machines, say eight or nine times the size of the present, were contemplated. But, to obtain the comfort required (and given by the ship) on a long voyage, the machines would need to be some fifty or a hundred times the size of the largest existing types. When

those sizes were reached, the problems of supporting the weight on the ground and of manoeuvring on the ground, taking off, and landing would become exceedingly difficult to solve.

Yet these problems are comparatively easy to solve in the large hydro-aeroplane. A large hydro-aeroplane with a high wing-loading could, if necessary, use the open sea as its aerodrome. Since the problem of the forced landing would definitely have been overcome by the power-unit arrangement, the large hydro-aeroplane would fly over land or sea. Its stations would be sea ports, lakes, or wide rivers.

The aeroplane both with moving and fixed wing will certainly grow in size; but nothing seems to me to indicate that it will be able to keep pace with the growth of the hydro-aeroplane. The growth of the hydro-aeroplane is foreshadowed in a French machine and a German machine which have appeared recently. The hundred-passenger hydro-aeroplane is a proven possibility. I can see no insuperable obstacle to the eventual arrival of the 1,000-passenger or the 2,000-

passenger hydro-aeroplane. Moreover, the fog-landing problem is easier to solve in the sea-going than in the land-going fixed-wing aircraft. Good automatic landing devices are more easily designed for hydro-aeroplanes than for aeroplanes.

Mr O. E. Simmonds, of the design staff of a firm of British flying-boat constructors, said: "The largest successful flying-boats yet built have weighed about 30,000 lbs. I shall certainly feel that progress has been inordinately slow if we have not constructed a boat of 100,000 lbs. gross weight *by the end of the next decade.*"

The first real air-liner, carrying some five or six hundred passengers, will probably appear after or towards the end ofthe battle between fixed and moving-wing machines. And it will be a flying-boat. The unsolved problems attending high-altitude air-transport seem to be so difficult that I am inclined to believe that high altitude transport will not become a regular method in this generation.

The possibilities of machines capable of travelling at immense speeds in the rarefied air at a height of 15 miles or so

from the ground are attractive. But, if a forecast is to be based on research-work actually accomplished at the time, it is made, then high-altitude flying must be excluded.

Among the problems which high-altitude flying involves and which seem to postpone its arrival to the distant future are: the infinitely variable pitch airscrew, the light, positive, infinitely variable gear (without ratchet final drive), the sealed cabin with self-contained ventilating system, the engine altitude supercharger, and the variable camber-wing. Among these the Leitner automatic infinitely variable pitch airscrew is one of the most interesting inventions ever made in airscrew design, but it is at present in its earliest stages. The Constantinesco torque-converter, which is an automatic infinitely variable gear, might be adaptable to aircraft. The sealed cabin presents great practical difficulties, as does the variable camber-wing.

From this brief parenthesis the difficulties of high-altitude transport will be apparent. It is almost certain to come, but its day is likely to be distant, and

for that reason I have concentrated on possibilities less remote.

Now that the long and short distance air-liners have been dealt with, I will give a brief sketch of how the traveller will use these vehicles. If Mr X, who lives at Hampstead, desires to go to Melbourne, Australia, he will first pile his luggage onto a taxi and drive to the terminus of some moving-wing aircraft line. This terminus will be close to the centre of London: A highly developed moving-wing aircraft will take him to the coast. The machine will land on the quay beside which will float a flying-boat express. This machine will be a fixed-wing flying-boat of about 1,000 tons. It will be a monoplane, the wings growing from the hull at a sharp dihedral angle and then curving down until they are horizontal.

The engines will be particularly interesting. Most designers, even now, are endeavouring to eliminate reciprocating motion in petrol-engines. The trend of thought is towards substituting the sleeve-valve for the poppet-valve and towards increasing the number of cylinders. More and more inventors "invent" gas-

turbines. Their engines have had varying degrees of failure, although a few, the Jean Mély turbine among them, are reported to have gained a measure of success. One of these inventors will soon be completely successful. The movement towards the rotary gas-engine is too vigorous and too general to remain for ever unfruitful. The gas-turbine will be the aero-engine of the future. It will be cooled by an evaporative system.

One pound of water carries only 20 B.T.U., whereas 1 lb. of steam carries 966 B.T.U. Wing Commander Cave-Browne-Cave, in a paper read before the Royal Aeronautical Society, drew attention to the advantages for aircraft of evaporative engine cooling. He said: "By far the lightest way of conveying heat is as the latent heat of steam." On test a standard aero-engine gave the same power and fuel-consumption with evaporative as with water-cooling. The greatest advantage will accrue in reduction of resistance. Panels in the aircraft surface will receive heat in the steam and thus the drag caused by water-radiators even of the wing or strut type, or air-cooled

cylinders will be eliminated. The evaporative cooling system will not freeze up at the highest altitudes: it will probably maintain the engine at a more even working temperature than an air-cooling system, and the steam will provide a suitable means of heating the passenger cabins and pilot's cockpit and of cooking.

The flying-boat to which Mr X is now having his luggage transferred then, has twelve evaporative-cooled gas-turbines housed in the wings, six on the starboard and six on the port side. Eight of them will drive tractor airscrews and four will drive propellers through torque-converters. There may be a system of concentrating the whole engine-power at three or four airscrews.

The entire machine, including the wing-coverings, will be built of metal. "I cannot conceive", said M. Dewoitine, the French designer, "that the ultimate aeroplane can be in anything else but metal, in the same way that metal ships to-day completely replace the wooden ships of days gone by." The living quarters in the hull would be arranged on labour-saving lines. The passengers

would have drawing-room, dining-saloon, lounge, and promenade deck. The promenade deck on a long-distance air-express will be different from the promenade deck on a liner. It will be enclosed in the hull and will be lighted by a transparent roof and sides.

Mr X finds his cabin arranged in much the same way as in a ship, and, having settled his things, he goes up to the lounge, where the other passengers are congregating. A few minutes later, with a faint hum, two of the tractor-airscrews begin to revolve, and the flying-boat moves slowly away from the quay. Two more airscrews start revolving, and the machine, having taxied out, turns into wind. It pauses a moment as if it were taking breath, then the twelve air-screws spin faster and faster until they appear as discs of light. The machine moves forward heavily, a solid mass of metal, with the passengers watching from the windows of the promenade deck. It lumbers through the water, but throws up but little spray. Then it seems to stretch itself, throw back its head, and to rise bodily out of the water until it runs

on the surface of—instead of in—the water. Already it appears lighter and less clumsy. Finally, after giving the water two or three parting pats, it takes to the air and, in spite of its great mass, instantly becomes an agile, graceful flying-machine.

The usual amusements, the usual eating, drinking, reading, and talking will employ the passengers' time in the air. For the daily round goes on in much the same way ashore, afloat or aflight. The night flying is exhilarating, although there is, of course, almost no sense of speed. Though the sea is rough, the machine, at 4,000 ft. is as steady as a rock. As the first stopping place rushes towards the machine, the hum of the engines alters note and the machine dips in a gentle glide. The mouth of a river, with shipping on it and two more flying-boat expresses lying at a quay a short way up the river, comes into view. The machine wheels round and glides closer and closer to the water. Four of the airscrews give a short burst of speed, and then the hull rips the surface of the water with a hiss.

Soon afterwards Mr X has said good-bye

to his voyage acquaintances who are disembarking, and the machine is off on the next stage.

The success of the large, long-distance flying-boat will mark the beginning of the concentration of fixed-wing machines on long-distance routes and the concentration of moving-wing machines on short, distance routes. The fixed-wing machine, finding it has no rival in the large flying-boat type and finding that it has a strong rival in the comparatively small land-going type (that rival being the moving-wing machine) will gradually remove itself from the short air-lines. The position will then be that all short air-lines are run by moving-wing land-going aircraft while all long air-lines are run by fixed-wing sea-going aircraft.

The real air-liner, as distinct from the commercial flying soap-box of to-day, will be an immense sea-going air-vessel. It will be a self-contained town offering greater attractions to the pleasure-seeker than any other kind of small town. When that machine makes its appearance the Air Age will have begun.

V

Before I described the passenger-carrying flying-machine towards which contemporary research-work seems directed, I postulated the freedom of the air for that machine. I stipulated that the statesman and the financier should be gagged and bound. Now that I come to private-flying and air-racing, however, the imagination jibs at the notion of a similar freedom of the air. If the statesman were prevented from meddling with the technical development of the passenger-carrying flying-machine, he would most likely turn with redoubled vigour to the task of controlling, organizing, watching over, regulating, and generally bleeding the private, the record-breaking, and the racing aircraft.

I can, therefore, sketch the future of those machines only as the statesman will direct it.

The small fixed-wing private flying-

machine, especially in the amphibian form, will gradually become more and more popular and, as it grows more popular, so the statesman will take more notice of it. His first opportunity for direct action will come when a few people get killed in an accident involving a private aircraft.

Taking advantage of the Press outcry, of the screams of the Safety First societies and of the opportunity for personal aggrandizement, Members of Parliament will pass a Flying-Machine Act.

Among the provisions of this Act will be a 40-miles per hour minimum speed-limit. No heavier-than-air craft will be permitted to fly at a speed of less than 40 miles per hour. It is easy to follow the workings of the official mind in setting this speed-limit. A fixed-wing aircraft crashes not because it goes too fast but because it goes too slowly. Therefore, the statesman will reason, if it is illegal to go too slowly, there will be no more accidents.

Another provision will make it illegal for anyone suffering from nicotine-poisoning to be in charge of a flying-

machine. (Prohibition will be established in England by this time, so that no clause about "drunk in charge of a flying-machine" will be necessary.)

Further regulations will make it necessary for every private pilot to pass a medical examination once a month as a condition of his having a pilot's licence. Having passed this examination, he will be required to wear, while in charge of an aeroplane, two 8-inch metal discs, with a number stamped upon them. One disc will be worn on the left shoulder and the other on the top of the flying-helmet.

The aeroplane, in addition to its letter markings on wings and fuselage, will be required to exhibit three plaques bearing identification-numbers. One will be on the centre section, one on the under-carriage, and one on the port side of the fuselage. The aeroplane will also carry metropolitan or county police markings on four tablets of given size, besides markings of the appropriate local council on plates of certain specified dimensions, and small circular pieces of paper con-

tained in approved holders on the rear port interplane-strut (or wing-tip in the case of a monoplane), the rear starboard interplane-strut (or wing-tip) the under-carriage port forward-strut, the tail-fin, the fuselage, and the top plane gravity-tank (if any).

In addition to the pilot's logbook, machine logbook, engine logbook, pilot's licence, and airworthiness certificate, there will be a registration-book, travel-triptych, flight-permit, landing-permit, and housing-pass.

These items are, of course, extra to the navigation-lights, wing-tip flares, cockpit-illuminants, parachute-flares, fire-extinguishers, silencers, life-saving parachutes, and other obligatory equipment, such as lifebelts, fire-proof bulkheads, stall-indicators, warning-signals, and Very lights.

These regulations will provide the police with the opportunity of displaying their keen sense of duty. They will ignore the old-fashioned and mundane murders, and will say with Horace Walpole: "Do not wonder that we do not entirely attend

to the things of earth; fashion has ascended to a higher element."

Conceive the vigour and elegance with which they will uphold the 40 m.p.h. minimum speed-limit. What their stop-watches (for they will still use them) and observation lacks in accuracy, they will make up for by the free imagery and sweeping poetic fancy of their evidence in Court.

The pilot who flies while suffering from nicotine-poisoning will be the object of universal opprobrium. His social doom will be sealed when the witness says that his breath *smelt of tobacco* and that he must have been smoking the same morning. The pilot's statement that he only had two cigarettes during the previous month will be completely discountenanced.

But the best chance for the police will come when the private moving-wing machine begins to make an appearance. Then will dawn the true constabulary millennium.

The moving-wing machine, as it has been shown, can almost hover and can fly comfortably at five or ten miles per

hour. One day a moving-wing machine will pass through a police-trap while its pilot is admiring the countryside or inquiring from his companion where they will stop for lunch.

The pilot will appear in Court charged with flying at less than 40 miles per hour, and there will be a sensation when the detectives disclose that defendant's speed, which he did not deny, was 8 miles per hour over a measured furlong.

The magistrate will say that, although he had been on that bench for thirty-five years, never in his whole experience, never from the moment that he had accepted those duties, never since the time when he devoted himself to the administration of justice, *never* had he heard of such a flagrant disregard for the safety of the public. Here was a flying-machine, over a populous area, travelling at 8 miles per hour when everyone knew that a flying-machine gained its lift by virtue of its speed through the air, and that if it travelled at less than forty miles per hour it was liable at any moment

to fall upon the heads of the people below.

The pilot might endeavour to explain the technical points in the case. If he did so, his fine would be greater than if he merely pleaded guilty and said no more.

That case will be the signal for a wholesale persecution of moving-wing aircraft-owners. The Home Secretary will issue warnings, magistrates will wish that they could send pilots to prison—in fact there will be the usual process of departmental browbeating which we know so well. The theory that the private flyer will not be summoned for slow flying because there will be moving-wing passenger aircraft also capable of slow flying, does not bear investigation. There are now lorries, motor-buses, charabancs, steam-wagons, and trams which persistently exceed the 20-miles per hour speed limit. They are not prosecuted, nor will the passenger aircraft of the future be prosecuted.

Having given some idea of the delightful future which lies before the private

flyer, I will add a few remarks upon air-racing.

After motor-road racing, air-racing is the finest sport yet invented. I give it ten more years life in England.

Before the War air-racing at Hendon was highly successful in that it attracted many entries and large crowds of spectators. Since the War air-racing has been unsuccessful. There are signs, however, that there will soon be a revival of it. Larger and larger crowds will collect to watch it. Special machines will be constructed, the number of entries will increase, continental firms will take part.

Then the statesman will step in and play his part, as he always must when anything becomes popular.

Air-racing is and will remain dangerous. Statesmen and newspapers will discover this and talk about it. Now I am informed upon the best authority that in England no one is allowed to face danger of any kind, whether he wants to or not. The State arranges that all dangers, physical and moral, are kept away from the individual. He may not do, see, hear

smell, or taste anything calculated to arouse him from the suety state of mind so highly esteemed by the politician. The Englishman is nursed from birth to death by an army of officials. He is permitted to risk his life only in war.

Air-racing, since it is dangerous, will gradually be stamped out of existence. Air-racing improves the aircraft as a machine-entity; it would have a good effect upon the private flyer's machine and upon the war-machine. When air-racing has been stopped, therefore, a decline in the quality of the private flying-machine and the service-machine will result.

Air-racing (with which I include record-breaking) is as important to pure aeronautical development as anything else. The history of the Schneider Cup seaplane-race is some indication of the technical advance racing achieves. In 1913 at Monaco the Schnieder Cup, was won by France at 45.4 m.p.h. In 1914 (England at 86.4 m.p.h., in 1919 (Italy) at 124.9 m.p.h. (This race was declared void). In 1920 (Italy) at 107.2 m.p.h. In 1921

(Italy) at 111.4 m.p.h., in 1922 (England) at 146.1 m.p.h., in 1923 (America) 177.4 m.p.h., in 1925 (America) 234.4 m.p.h. and in 1926 (Italy) at 246.5 m.p.h. (Fig. 3).

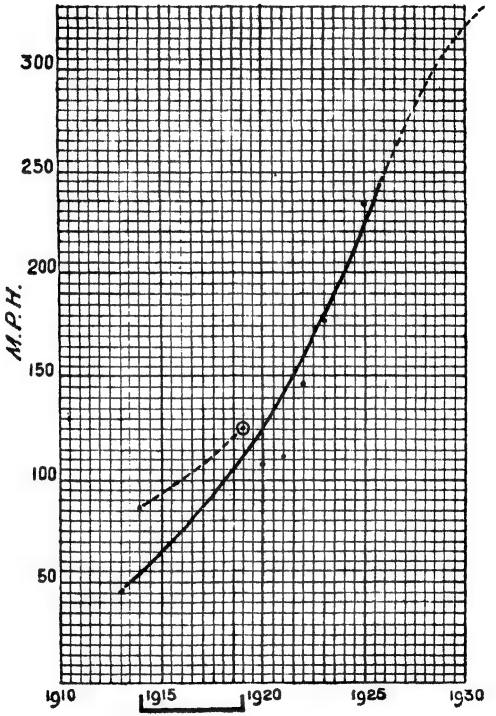

Fig. 3 Schneider Cup

The Schneider Cup figures show that the much boasted rapidity of progress in the performance of high-speed aircraft during the War is a myth. During the War, progress was almost completely stopped. Even if the Italian win of 1919 at 124.9 m.p.h. be accepted (and the race was declared void because Janello was not observed at one of the turning-points) the rate of progress compares unfavourably with the rates before and after the War. If, on the other hand, the rate be judged by the accepted wins of 1914 and 1920 then the top speed of seaplanes rose only 20.8 m.p.h. in 6 years against 139.3 m.p.h. in 6 years after the War.

Up to 1926 there has been little sign of a falling off in the rate of progress in high-speed seaplane-design, and a rough estimate, puts the probable speed of the winner in 1928 at 290 m.p.h. and in 1930 at 320 m.p.h.

Record-breaking has a similar effect to racing upon technical development. In 1919 Sir John Alcock and Sir A. Whitten Brown flew the Atlantic non-stop for the first time in a heavier-than-air machine. They covered 1,890 miles in about 16

hours. In 1926 M. Dieudonné Coste and Capitaine Rignot covered 3,400 miles non-stop in 32 hours.

Whatever country takes up and encourages private flying, air-racing and record-breaking will play a big part in the future of the flying-machine.

VI

I see no reason to depart from the forecast of the future military flying-machine which I make in my *Strategy and Tactics of Air Fighting*.

Since the fixed-wing machine will probably retain a slightly superior performance over the moving-wing machine (although it is fair to Señor de la Cierva to add that some of the best mathematicians find on theoretical calculation that the moving-wing aircraft should be equal in all-round performance to the fixed-wing type), it is likely that, excepting a proportion of army co-operation machines and a small proportion of night-bombers the moving-wing machine will not in the future be used in large numbers for war purposes.

Before constructing the machine of the future, let us go to the R.A.F. annual Display, and refusing to be fascinated by the intricate shape of the breeches worn by officers and men, let us examine

an experimental single-seater fighter of the present. When in the air the machine is remarkable only for the undercarriage-struts and wheels which hang below the fuselage. They look like a labourer's hands in the drawing-room, they are sturdy but, in the air, they do not seem to know what to do with themselves, they are in unaccustomed surroundings.

Let this machine be compared with the gull. I use the gull for these comparisons because it is common and easily observed and so provides an accessible model. Indeed, it was the gull which instructed Mr A. V. Roe and helped him to become, on June 8th, 1908, the first man to fly over British soil. The experimental single-seater fighter at the R.A.F. Display has very few characteristics of which any bird need be ashamed. One of these characteristics, however, is undoubtedly its undercarriage. The gull folds up its undercarriage when it is in the air; it lets it down only when it is about to land.

But now compare the experimental machine with one of the standard machines in an R.A.F. squadron. The standard service-machine looks as if it has got into

the hands of an accessory fiend, one of those who believe that the part is greater than the whole. It is so cluttered up with odds and ends, so cut about, modified, added to, and altered that it resembles no other flying-machine, animal or artificial. It is a sort of winged Air Ministry, a receptacle full of interesting information about everythng but the air.

Since this mania for encumbering service-machines is only a superficial failing, it is possible, after remarking it, to go direct to the service-machine of the future.

There is first a new type to be noted, the aerial artillery-machine. This will be a large multi-engined monoplane carrying a single medium-sized gun and a few rounds of ammunition. It will be able to direct close range gunfire from the air at important ground-objectives. The advantage of the aerial big gun over the bomb will be in accuracy, the advantage of the bomb over the aerial big gun will be in the great weight of projectile made possible by the absence of any heavy launching-apparatus like a gun. The

height of the aeroplane acts on the bomb as the explosive charge on the projectile. But at long ranges the bomb, with the newest sights and under the best conditions, is inaccurate, and at short ranges its velocity is low. The aerial big gun permits ground-objectives and ships to be attacked at short range with projectiles travelling at a high velocity.

The success of low-flying attacks by machine-guns in the late War was a sufficient demonstration of the potentialities of the low-altitude gun-attack from the air. Experiments were made long ago in mounting small guns in aeroplanes and in arranging for the absorption of the recoil. Against other aircraft the aerial big gun would not be used. In aerial fighting weight of projectile is of less importance than rate of fire.

The night-bombing machine of the future will be an immense flying-boat. It is likely that this type will also be used for day bombing. If so, it will be heavily armed with machine-guns and will not go out without a strong screen and escort of fighting machines.

The fighting aeroplane will be particularly interesting. It will be a small monoplane without external bracing-wires or struts and the undercarriage will be retractable. It will carry one man, and will be an all-metal machine mounting a gas-turbine of some 1,000 h.p.

Performance-figures must be the wildest guess work, because the closest examination of the trend of research gives but small information on the probable rates of progress in speed and climb. Mr A. V. Roe has frequently stated his belief that the future flying-machine will attain 1,000 miles per hour. I will, therefore, give my fighter of this generation 400 miles per hour, 800 miles per hour in the dive, a climb to 20,000 feet in 4 minutes, and a service-ceiling (the height at which the rate of climb falls below 100 feet per minute) of 60,000 feet.

In order that the fighter may operate at high altitudes, and in order that it may be able to change height suddenly by diving or climbing steeply, the pilot will be housed in a pressure-cockpit, from which he will look through a streamline conning-tower made in some trans-

parent material. Unless he were enclosed in some such pressure-chamber or pressure-suit, the pilot would be unable to withstand the cold and the reduced pressure of extreme altitudes, and the sudden changes in temperature and pressure, when the machine was climbing or diving. Pressure-suits are now being experimented with in France and probably elsewhere.

Oxygen would be supplied to the pressure-chamber and an emergency oxygen-apparatus would provide against the chamber being pierced by a bullet. Some form of dessicating apparatus would be essential to prevent the transparent conning-tower from fogging up. The fewest accessories would be carried by these fighters of the future.

In general military aircraft will be more specialized than they are to-day, there will be no many-purpose machines. Instead, the number of specialist machines will steadily increase. In addition to the aerial big guns, there will be flying-tanks or lightly armoured low-flying machines for attacks on ground-targets. These will be developed from the " Salamander ", " Vampire ", and other armoured air-

craft introduced during the late War.

Armour for fighting and bombing-aircraft will not be employed for many years. The gunners on the large flying-boat bombers, however, will be provided with small shields.

Perhaps a general idea of the future of the flying-machine in war may best be given by quoting a newspaper report of a day air-attack on London in the next war.

I cut the headlines and start with Our Special Correspondent, who, with the printer's assistance, has, if I may be permitted to say so, trodden on it through all four gears :

" The greatest air-raid in history was launched on London yesterday evening by a formation estimated at between six and seven hundred aeroplanes.

" For nearly two hours the earth shook to the thunder of the guns, while far up in the blue vault of Heaven there was the flash of wheeling wings, as the heroic pilots of the Royal Air Force plunged again and again to the attack.

" Never before has the heart of

the Empire been the objective of so powerful and so determined an offensive, never before have the British air-forces so covered themselves with glory.

" Owing to the vigorous defence which met the raiders as they neared London, casualties are low. Official figures have not yet been issued, but it is thought that fewer than 1,000 people were killed while only some 7,000 were wounded.

" FIRST WARNING.

" The raiders were first reported by the ' concrete ears ' or wireless disc and super-sensitive microphone sentries which encircle the coast. A large formation (there was much doubt as to the number of machines) was said to be approaching Southampton, and with the exception of three emergency squadrons, every R.A.F. fighting-aeroplane rushed to the attack.

" As our machines, sweeping through the freezing blue of the great altitudes,

approached the raiders, the raiders turned and made off at full speed. Our machines bent on reaching the enemy, tore after them.

"It was at this moment that ominous news came through. A second hostile formation, far larger than the first, had been detected approaching the East coast south of Harwich.

"Nearly the whole of the defending airforce was far away: London's bosom was bared to the attack.

"The new formation—first given as 400 machines but later corrected to 600—was in four great layers and flying at 170 miles per hour.

"The three emergency R.A.F. squadrons, numbering 54 machines of an old type with five or six experimental machines from Martlesham Heath and Farnborough, went up at once and hurled themselves at the vast enemy formation.

"THREE TO ONE ODDS.

"The second layer of the hostile formation, which consisted of about 150 long-

distance fighters, engaged them. A furious battle ensued, while the remainder of the hostile fleet, aerial big guns, flying-boat bombers, and, at an extreme altitude, a further batch of long-distance fighters, continued on their way towards London.

"The old R.A.F. machines were literally butchered by the whip-lashes of lead which cracked and curled from the small-calibre stream-fire enemy guns. One of our machines had both its wings cut off and fell to the ground with such force that the airscrew-boss was buried 18 feet in the earth.

"Meanwhile wireless messages had reached the R.A.F. formation, which had been drawn off by the feint attack on Southampton. *They had turned and were tearing to the rescue at* 350 *miles per hour.*

"The two big formations were in sight of each other when the enemy was about 20 miles south west of Chelmsford. At this time there was no active opposition to the invaders in the air. Anti-aircraft batteries, however, were blackening the sky with shells, and had succeeded in bringing down two enemy machines.

" There seemed now no hope that London would escape the full force of the attack. Already two ten-ton wireless-controlled flying-bombs had struck the city. Even so there was little panic. The gas-mask distribution had worked well, and no one was unprovided. The usual shelters were made full use of, but many people, against the orders of the police, remained in the streets anxiously looking skywards and listening to the almost continuous tear and roar of the guns.

" ANXIOUS MOMENTS.

" For some reason the news that the first hostile formation had retired had not come through on the wireless. And, since no one knew that far the greater part of the R.A.F. defending forces had gone in pursuit of that formation or that the emergency squadrons had been cut to pieces, a good deal of uneasiness prevailed among the watchers.

" Where are the R.A.F. fighters? was

the question uppermost in everyone's mind.

" As the noise of the guns grew louder and seemed to vibrate and echo among the houses, considerable alarm was displayed. There were one or two ugly scenes, and some women and children were trampled to death in raid shelters at Hoxton and Liverpool Street.

" A quarter of an hour before dusk the two lower layers of the hostile formation were sighted by some people who had been foolish enough to take up positions on the roof of the *Daily Post* offices in Fleet Street. Only the trained eyes of the anti-aircraft spotters aided by the new visual detection instruments could distinguish the upper layers.

" Still there was no sign of our aeroplanes. The stories of those irresponsible alarmists who, in books and articles, have prophesied as far back as 1927 that London would be wiped out by aerial attack, seemed likely to prove too true. Excitement among the watchers gave way to a certain grimness. Then came a change in the situation.

" " What's that ? "

" THE BATTLE JOINED.

" Someone was pointing immediately overhead. Nothing could at first be distinguished in the blue sky; then someone else waved excitedly.

" " Yes, I caught a glimpse."

" Just then the light of the setting sun glinted momentarily on some infinitesimal speck like a minute silver fish, rushing through the air at a great height. No one dared to express the hopes which they felt.

" A moment later what looked at first like a small red rose sprang into being high up over the enemy, high over the smoke-blackened sky where the anti-aircraft shells were bursting. Then it fell, like a flaming bomb. There was fighting going on up there, out of sight, in the upper air.

" Still the lower hostile layers came on through the roar and shock of the anti-aircraft fire. They were already over the outskirts of London. Something else fell from above twisting horribly. The white of parachutes drifting fantastically

could be observed through high-powered glasses.

" Quite suddenly the continuous thunder of the anti-aircraft fire ceased. It was succeeded by an uncanny calm, and then by a high-pitched metallic scream which grew in an ear-piercing crescendo. *The R.A.F. aerial destroyers were engaging the lower enemy layers.*

" The R.A.F. arrows of the upper air plunged into the very heart of the raiders, streaming fire and lead. They wheeled and turned among them with a swift, purposeful agility.

" RAIN OF BOMBS.

" The hostile formation began to split up, and simultaneously the enemy commander gave by wireless the order to bomb. On the outskirts of London huge factories and houses were suddenly transformed into pillars of white dust. The shriek and thump of the falling bombs was heard clearly in Central London.

" ' It was as if the ground were being torn up under your feet ', said a postman eyewitness. ' The people in the shelters

came out and began to run. They didn't stop to think; they just ran like wild beasts, trampling on each other, and hitting out at anyone who got in the way, whether man, woman or child.

" ' The rain of bombs was so continuous that for as far as you could see earth and buildings were spouting up in the air with human limbs mixed up in them. The sound of the bombs falling was what knocked people's nerves up as much as anything.

" ' The gas-bombs didn't seem so bad, but the incendiary bombs were a nasty sight, at one time it looked as if the whole air had caught fire.'

" According to official information, damage was small. Only the aerial artillery-machines attained an objective of military importance. They completely destroyed the F.E. aircraft factory at Finsbury Park.

" The raiders had timed their attack so as to escape in the dark, and, although the new night detection flood-lights worked well, there is no doubt that the hostile casualties were so few because our fighters were hampered by the darkness.

"According to figures supplied by the Air Department of the War Ministry, 37 hostile machines were brought down while only eighteen of our own aerial destroyers were lost. The three emergency R.A.F. squadrons which first attacked lost 39 machines and had several more severely damaged.

"The raid is regarded by experts as a decisive victory for the British Air-arm and a complete and convincing justification of the policy of the Air-staff. It is pointed out that the raiders were prevented from reaching their objective, and that, apart from the old-type R.A.F. machines, our casualties are smaller than those of the enemy."

In another part of the same paper was this insignificant paragraph.

"A late Central News message, delayed owing to the disorganization caused by yesterday's air-raid, states that the hostile formation which made a feint attack on Southampton and was driven off by our machines, later returned to the same place and bombed it continuously

for half an hour, causing many casualties and much material damage."

In the stop-press news was this :

"One a.m. Large hostile formation of aircraft reported approaching mouth of Thames."

In the above skit I have not dwelt on the terrible side of air-warfare in the future. Yet I feel that that is the side upon which all who are competent to do so, and who wish to prevent future wars should dwell. Several novels have given pictures of future aerial warfare, but I have not seen its inevitable horrors realistically portrayed. Unless those horrors are portrayed frequently and in their true and shocking form, people will soon forget the unpleasant side of air-war and think only of its romantic and glorious side.

In the interests of humanity it would be a good thing if some able novelist or film-producer would give us a statement of the crude horrors of air-war. If such a one arises, he will have the satisfaction of having helped the cause of peace and of having his work banned by the Censor.

VII

So far I have spoken only of heavier-than-air flying-machines. There is also the airship to which many people pin their faith for future long-distance air-transport.

The airship was neglected in England after the War because experience seemed to show that it was incapable of playing a useful part in warfare. Its revival was chiefly due to Commander Burney, who continually drew attention to his conviction that the airship could be made a safe and successful long-distance air-transport vehicle.

Most airship advocates believe in the bigger the better theory. If the gas-capacity of an airship is doubled, the disposable lift may be quadrupled, and the size will be only about 1.3 times that of the smaller vessel. For this reason the two English airships now being built are each of 5,000,000 cu. ft. gas-capacity.

One is being built by the Government, the other for the Government to Commander Burney's general design.

These airships have provided matter for many speeches on Empire air-ship-routes of the future. At the recent Imperial Conference airships were spoken of as the right vessels for long-distance air-lines. These forecasts are based on slender foundations.

Since 1914 only one successful commercial airship-service has been run. The 'Bodensee' in 1919 made 103 trips between Berlin and Friedrichshafen and carried 2450 passengers. Those 103 trips seem to be an insecure basis upon which to build calculations about voyages halfway round the world. The new airships may go from England to Egypt in 2½ days, and from England to Melbourne in 12½ days, but nothing has occurred in airship-development to strengthen the probability of such events. The two new airships are nothing more than a gigantic experiment.

I must make some unpleasant remarks about airships, but, before doing so, it is necessary to record admiration of the

English airship policy. I do not agree with the man with a genius for mixed metaphor who described the airship scheme as the " thin edge of the white elephant ". On the contrary, in initiating this experiment the Government has shown imagination and daring. Airship enthusiasts are to have an opportunity of testing their theories. If the experiment is a hopeless failure no money and no time will have been wasted, for the knowledge gained will be of value in directing future aeronautical development.

But to the question : Will the airship become the long-distance air vehicle of the future ? I answer No.

I base my view on an examination of airship history and on the opinions of airship pilots. Upon that basis the probable future of the 5,000,000 cu. ft. vessels will be this :

The first one to be completed will make a first flight, and come to its 200 ft. mooring mast successfully. For several months it will cruise periodically, and minor structural modifications will be

made. It will fly to India and back. Paying passengers will be accepted, and after considerable delay the first long-distance passenger-flight will be flown. Some two or three years after the airship comes from its shed, it will meet with disaster.

More airships will be designed and built, larger still than those now building. There will be another disaster.

By then the heavier-than-air machine in the moving-wing and fixed-wing forms, will have proved itself capable of doing all that airships can do and doing it more safely, more quickly, more regularly, and more cheaply. The airship will gradually disappear, and its place will be taken by the heavier-than-air craft, as the balloon is gradually disappearing and its place being taken by the airship.

There is only one major difference between balloon and airship, a difference in the amount of control exercised by the airman. The same difference exists between airship and aeroplane. The aeroplane is the more controllable. It can rise and descend with less preliminary

juggling ; it can turn more quickly ; and it can land more quickly.

In support of my pessimistic forecast I append a brief outline of air-ship-history.

Lighter-than-air man-carrying flight started in 1783 when Pilâtre de Rozier, the world's first aeronaut, went up in a Montgolfier balloon. In the same year a hydrogen filled balloon flew from Paris to Nesle. In the following year an oblong balloon propelled by parasols as oars was made by the Duc de Chartres.

In 1852 a small airship propelled by a steam engine was made. In 1882 Tissandier's airship worked by an electric motor was flown, and in 1884 the airship 'La France' was flown. Count Zeppelin built his first airship in 1900. Santos Dumont constructed an airship, and, in 1902, flew it round the Eiffel Tower.

It will be seen that the airship has passed through a longer period of development than the heavier-than-air flying-machine, even if the claim that Clement Ader flew in 1897 be accepted. Lighter-than-air flight, indeed, dates back to 1783.

The result of that longer development period is not such as to warrant too sanguine a belief in the airship's future. The accidents to non-rigids and rigids have been many in proportion to the number of vessels actually flown.

The last type of non-rigid built in England was the North Sea type, one of which was destroyed by lightning soon after the War. Nine people were killed. Among the rigids, R.34, which made the double Atlantic crossing, was damaged beyond repair in 1921. R.33 has had many adventures, among them being her break-away from the mooring-mast in 1925. This was hailed as a proof of the safety of airships. R.33 is still alive, though she is treated with the respect due to her age.

R.36, the first British airship to be adapted for commercial purposes, is still in existence though not in service. R.38 broke up over the Humber in 1921 and forty-four people were killed.

The U.S.A. have the 'Los Angeles', which is the name now given to the German designed and built ZR.3. The

'Shenandoah' broke away from her mast in 1924, and was destroyed in 1926. According to survivors' stories, the 'Shenandoah' was wrecked by the same kind of vertical air-currents that wrecked an early Zeppelin in 1913. In all, nine American airships have perished violently since the War.

The French 'Dixmude' was the ex-Zeppelin L.72. She created a world's record in 1923, and then disappeared off Sicily with all hands (54 people).

Considering how few large airships have been built, and how short a time they are, on the average, kept in service, the proportion of serious accidents is high. In war that proportion is prohibitively high.

The Zeppelin works have turned out more rigid airships than any factory in the world. The fate of every Zeppelin airship completed since 1915 was recently given in a French technical paper. I do not vouch for the figures, but they come from a fairly reliable source. Out of 76 airships no fewer than 37 (or nearly 50%) were put out of service before they had completed one year's work. Only

four airships were kept in service for more than three years. This is the record of the firm which knows more about airships than any other firm in the world. Yet airships have had longer to develop than aeroplanes.

How can an airship be said to be superior to a fixed-wing aeroplane? It can hover, it has a longer range, it provides a higher degree of comfort for its passengers. How is it inferior to a fixed-wing aeroplane? It is slower, it requires more elaborate ground organization, it is less controllable. Since the moving-wing aircraft is, as yet, far from fully developed, I leave it out of discussion.

The argument that an aeroplane is always using a part of its power for lifting is counterbalanced by the argument that an airship is always using a part of its power for driving its bulk against the wind. An airship cannot stand still and use no power. There is always some wind at a height, and the airship must either use power or drift. An airship with all its engines stopped is as helpless as an aeroplane with all its engines stopped.

The aeroplane, while gliding, still retains a large measure of controllability, and the pilot can select its landing ground within 50 yards. The airship has less controllability when its engines are stopped Its commander would be lucky if he could select its landing ground within 50 miles.

It is right that the airship should have every chance to develop. If it prove successful, so much the better. I do not think it will prove successful. If it is made to work, it will be at more than ten times the cost in money and lives, at which heavier-than-air machines have been made to work.

Sometimes it seems regrettable that even a small part of the sums spent on developing airships cannot be spent on developing the passenger-carrying aeroplane.

I will give airships the last word by recalling that Sir George Cayley in 1816 expressed his belief that airships would eventually prove the most efficient and safest means of air travel, and by quoting Dr Eckener :

" A modern airship ", said Dr Eckener,

" is at least as capable in heavy weather as a modern aeroplane. A storm will never have more effect than delaying or speeding a trip, and it can become directly dangerous only inasmuch as it may delay the voyage beyond the reach of fuel supply."

VIII

" Sans nul doute, l'avenir est a la bête de métal." People regret the age of the machine : I cannot do so. A well-made machine, in which are struck into life the dreams of its designer, is a vital, individual creation.

A flying machine designed by a man with a sense of flight is more faithful and far more intelligent than a horse or a dog. Thoughts are reflected in it, the careful skill of the executant is expressed in its every component. It is sensitive and quick to feel roughness or gentleness in the hand of him who controls it. Its moods are without number, and it can surprise, please, and irritate. It is susceptible to being coaxed, and it enjoys obeying one whose orders are firmly given. But it can be treacherous to the weak or to one who does not try to understand it or who is persistently cruel to it.

At present there is a tendency to knock the life out of the machine, to subdue

it to the level of tooth paste and tin cans. If that tendency makes headway, the flying-machine of the future must lose its individuality, and the age of the machine may eventually prove to be a dark age.

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